MAN AND MICROBES.*

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I. PRIMITIVE MEDICAL PRACTICE.

SINCE the very beginning of man—and that was a long time ago—until comparatively recent times, demons and disease have been inextricably linked together in the human mind.

Archæological, historical and ethnological literatures abound with narratives respecting the relation of spirits to illness. Babylonians, Assyrians and Hindus alike held that the air was peopled by spirits, chiefly of the evil, aggressive kind, that scattered havoc and destruction among mankind. Even at this late day of boasted civilization we may state with assurance that seven-eighths of the world's population are firm believers in the demonological etiology of disease, and proceed to treat it as they did in the very earliest period of man's existence, with incantations, amulets, charms and talismans.

I shall attempt only to outline this evening the development and progress of those activities directed towards an understanding and control of the invisible destructive forces responsible for disease and death.

The oldest medical treatises known are the Petrie Papyrus, discovered near El Sahun and dated 1600 years B. C.; the Papyrus Ebers, dated about 1500 B. C.; the Berlin Medical Papyrus, dated about 1400 B. C., and the British Museum Papyrus, which was written some 1100 years B. C. In these papyri are formulæ for cures which were administered in the form of incantations and by the priest physicians. A prescription for diseases of the eye reads as follows: "Let one take a human brain and divide it in half. Let one half of it be added to honey, and the eye be annointed with this in the evening. The other half should be dried and finely ground, and it may be then used for anointing the eye in the morning."

All primitive worship of invisible forces has been directed towards some symbol, such as idols, etc. Naturally there were, to these races, good spirits who successfully combated the evil ghosts of disease. Worship of this god of cure was manifested among the Egyptians in their I-Em-Hotep, or god of medicine —a little bald-headed man. It seems that baldness and learn-

* Illustrated lecture given under the auspices of the Kansas Academy of Science, Topeka, January 12, 1917.

ing were associated even in that far distant time. It was he who assuaged the weary, who cast out the devils of disease, who gave sleep to the sleepless.

II. EARLY GREEK MEDICINE.

Since our civilization began with Greece, naturally we are more interested in the medicine of early Greece. Medical practice among the early Grecians was inextricably interwoven with its mythology. Apollo was the father of Æsculapius, who in turn was the sire of Hygeia. Hercules, Jason and Achilles were taught medicine by the centaur, Chiron. Æsculapius was the early Greek god of medicine. Like I-Em-Hotep, he was probably a man who later became apotheosized, and numerous temples were built to him. The most famous of these sanctuaries was Epidaurus. In the abaton the sick slept and were healed.

In many repects the surgeons of that period (300 B. C.) were far more determined and worked under more difficult and exciting conditions than does the modern surgeon. The surgeon of that remote date, above everything else, had to excel in physical strength and speed. For as anæsthetics were unknown, an operation was the equivalent of a battle royal, prize fight or wrestling bout. Generally the surgeon won out, but not until after several rounds had been "gone to" between the patient and himself. Further, the conflict was not always limited to the area of one ring. If the patient succeeded in breaking loose, then the element of speed came in. When the patient was overtaken the operation proceeded. Under these conditions track work might well have been one of the pre-medical requirements. Imagine a major operation being performed on the University campus. Let it begin at the Museum Building and finish at the Engineering Building, with Fraser, Snow Hall, the Gymnasium and the Geology Building as sanguinary sites of successive steps in the operation. The path followed by the frantic, unyielding patient and the benevolent, determined surgeon would be marked by a trail of red.

So much for the wonderful achievements at Epidaurus.

III. HIPPOCRATES.

Medicine in reality dates with Hippocrates, the Father of Medicine, and probably a descendant of Æsculapius. Hippocrates lived in that brilliant period of Athens when mythology

was rapidly vanishing in the light of reason. It was in that age that Pericles ruled Athens, that Socrates taught, Plato wrote, and Phidias carved his statues. Then myth and fancy began to give way to reality and fact.

Hippocrates rationalized medicine so far as it was possible in his time. He endeavored to eliminate all that was mystic, all quackery. He gave origin to the theory of the four humors of the body—blood, phlegm, black bile, and yellow bile. According to him, disease was not due to the visitation of some angered god, but to a disproportionate admixture of these humors. A practical physician was Hippocrates, for he bled, poulticed, dieted and purged his patients. He prescribed diets and recommended fresh air. Further, he was truly scientific in his bent, for he took up experimental study. Much of his knowledge of digestion was attained through feeding certain willing patients and then forcing them to vomit at definite prescribed intervals. A keen observer was Hippocrates, and some of the symptoms (Hippocratic facies) described by him are recognized in present-day diagnosis. Honor is due him for having prescribed the best code of conduct and morals that a physician can adopt—the oath of Hippocrates.

Time and space will permit us to name only the salient features in the progress of medicine from the time of Hippocrates until that period which marks the discovery of the various microbes of disease. Let us leap from one conspicuous contributor to another. After Hippocrates came Aristotle, better known for his philosophy than for his science. Then the establishment, by Alexander the Great, of the great university in Egypt. Here, while Euclid demonstrated his propositions and Ptolemy studied the moon, Erasistratus and Herophilus carried on their dissections of the human body.

IV. GALEN.

Later, we note the fall of the Alexandrian school in 414 A. D., and the center of higher learning transposed back to Europe. Rome became the center of the civilized world. Here appears the second great apostle of medicine, Galen. He was a Greek by birth, educated at Alexandria, and went to Rome, where the highest intellectual agencies began to center. While Hippocrates dominated medicine for a period of 500 years, Galen was absolute authority in medical practice for more than a thousand years. He was the first noted experimental physi-

ologist. Much of his activity was directed towards proving that the brain, instead of the heart, was the center of the nervous system. The latter view was held by Aristotle, who further held that the brain acted only as a sponge, to cool the heart. Galen cut the spinal cord of animals, which induced paralysis. He proved that the kidneys secreted urine.

With the death of Galen medicine fell a victim of the times, so far as Europe was concerned. It was buried in the long period of the Dark Ages under that reversion to mysticism, demons, incantations and charms which characterized the Dark Ages—the age when the church arrogated the sole right to be the arbiter of all knowledge. However, through one of those strange happenings, of which history is full, the contributions of Hippocrates and Galen were not entirely lost.

V. MOHAMMEDANS AND MEDICINE.

Strange to say, the saviors were those dark-faced Asians who had set out with the crescent and scimitar to annihilate the Christians. Not long after Mohammed's death, practically all of eastern Asia and northern Africa was subjugated to those who held: "There is only one God, and Mohammed is his prophet." Notwithstanding that the Mohammedans burned the immense, priceless library of Alexandria, still the Khalifs and their Arabian followers became the earnest and enthusiastic patrons of ancient and classical learning. It happened that at Constantinople there was a school known as the Nestorians, who pertinaciously clung to the old order of learning, despite the fact that the church had otherwise decreed. They were consequently banished from Constantinople, A. D. 431, and went to the valley of the Euphrates, where they founded a church and a medical school, and there proceeded to continue the study and teaching of Grecian learning. The Khalifs of Bagdad welcomed them with open arms. The Nestorians translated into the Arabian the Grecian classics, and became the teachers of Khalifs. Even the famous Haroun-al-Raschid included always a hundred learned men in his traveling retinue. Galen was translated, and was elevated almost to the dignity and rank of the Koran. The Arabs became deeply interested in chemistry—perhaps alchemy is a better term for their activities. At any rate, nitric acid, sulphuric acid and phosphorus were among their discoveries. Arabian

medicine, however, did not advance, for it was sacrilege to touch a human corpse. And without anatomy and physiology there could be little progress.

VI. MEDICINE IN THE DARK AGES.

Throughout the entire Dark Ages, when a false theology held sway, and had throttled every inception of knowledge, medicine, of course, did not advance. On the other hand, like every other science, it retrograded as a result of the unmerciful suppression given it by the hierarchy of the times. Assuredly Europe was in a state of extreme intellectual stagnation. At the end, however, of a thousand years of darkness the dawn came, and, curiously enough, it was those dark-skinned builders of mosques who contributed much to the European twilight.

Through Arabian commentators and Latin translators Europe was again given much of the knowledge that was its by birthright. Constantine, the African, translated Hippocrates and Galen. Thus Europe again became familiar with these two early master teachers of medicine.

From the tenth to the fourteenth century medicine in Europe was augmented by the immigration of Jews versed in Arabic medicine. With the fall of Constantinople, in 1453, the study of Greek was further stimulated by learned Greek scholars who migrated from that city to Rome. Then Greek manuscripts that had been buried for centuries reappeared. A discovery of the original manuscripts of Hippocrates and Galen was made. It was found that the translations of the Arabic did not entirely agree with those of the original. This led to a noted controversy, which even took a religious character. Thus did the influence and contributions of these two men serve once more to stimulate the spirit of investigation, which began with the Renaissance.

Roger Bacon, Columbus, Copernicus, the printing press—all played an important role in the revival of learning. The resurrection of the study of anatomy in the middle of the sixteenth century marks the real rebirth of medicine. Sylvius, Versalius and Fabricius each in turn contributed to the science of medicine. To Versalius in particular we owe much, for he it was who dared to ignore Galen's teachings, for the first time, and trust to his own observations. Even Sylvius con-

demned him for this disregard of authority. Following Versalius came Harvey with his monumental discovery of the circulation of the blood.

VII. THEORY OF MICROBES.

Medicine now took many avenues of progress. It is with the rôle that the microbes play in disease that we are especially concerned, and we must now limit ourselves to those activities concerned with the development of the germ theory of disease.

It was in the seventeenth century—the century made famous by Shakespeare, Bacon, Milton, Harvey, Malpighi and Galileo —that the Dutch lens maker, Leeuwenhoek, began his studies of these minute agencies of death. Perhaps the honor of the discovery of the microscope belongs to Galileo, as this instrument is so closely related to the telescope. At any rate, while he studied the firmament, Leeuwenhoek began the study of the infinitely small life forms that surround us. He saw animalculæ in water and saliva. He was interested in the origin and size of these microörganisms. Not until two hundred years afterwards however, was the great significance of Leeuwenhoek's discovery appreciated, when the relation of these invisible life forms to disease was realized.

Just when the germ theory of disease had its inception is difficult to state. Like most great truths, it was likely the growing product of many centuries. Sir Harry Johnston has said:

"Not only did the growing culture of Neolithic and early metal ages begin to preceive danger in the fly, in the locust, bug, tick and mosquito, but an instinctive dread was felt of the invisible germ, the minute organisms which were not to be visually perceived by men till the seventeenth century of the Christian era, and not to be in reality appreciated and understood till about fifteen years ago. The instinctive belief in the "germs" and the spread of the germ diseases was undoubtedly at the basis of the preposterous class regulations developed by the Aryan invaders of a Negroid, Australoid, India."

One of the oldest specific references to the rôle that germs play in the causation of disease is found in the "De Re Rustica" of Tarentus Rusticus, who states:

"If there are any marshy places, little animals multiply, which the eye cannot discern, but which enter the body with the breath through the mouth and the nose and cause grave diseases."

Columella and Kirscher propounded the same theory even before the time of Leeuwenhoek. To the latter, however, belongs the credit of first having viewed these microörganisms.

His discoveries were not utilized until two centuries later, but numerous writers of the next century in theory taught almost precisely the relation of germs to disease. This was especially true of Plenciz and Bassi.

VIII. JENNER AND SMALLPOX.

Long before the first bacterium of disease was discovered and convicted, one of the most serious of the infectious diseases of mankind was subjugated and placed under control through the ingenuity and efforts of one man, so that now it has become one of the optional diseases. Like elective courses in the University, one may take the disease if he so desires; otherwise not. I have reference to smallpox, the great "scourge of God" that for centuries, with irregular and frequent periodicities, brought havoc upon mankind.

That vaccination for smallpox was practiced among orientals centuries ago is a verisimilitude. In all likelihood, even before the Christian era, the custom of introducing smallpox scales into the nostrils—"sowing smallpox—or of opening the pustules of the victim and transferring some of the suppuration to an incision on the one to be inoculated was practiced in Hindustan. Such practices occurred in northern Africa, among the Chinese, Persians, Circassians, Greeks and Turks. Even in northern Europe and Great Britain the principles of inoculation were doubtless known and practiced more or less sporadically and on a minimum scale for a long time.

To Lady Mary Montagu belongs the honor of introducing the practice into England on a more or less national basis. Owing to her court relations, she succeeded in converting the royalty, and when royalty once adopts a custom imitation on the part of many of its socially aspiring subjects assures its permanency. Our worthy lady had been visiting in Constantinople, and in a famous letter, 1717, she told of how she had rendered her boy immune to the disease by engrafting—a practice so common among the Turks. So enthusiastic had Lady Montagu become over the practice that upon her return to England she succeeded in converting the Princess of Wales and a host of the king's court to the procedure.

Despite these measures, the ravages of smallpox were not materially reduced. The public fought shy of vaccination. Always was the clergy ready to oppose it. "Horrid murder of the little, unoffending innocents," said the robed ecclisiastics.

Probably one child in fourteen died from smallpox. Pocked faces were as common as normal visages. Again there was a serious objection to this practice, founded upon good judgment, and that was that other diseases could be communicated from one individual to another as a consequence. Further, one never knew just to what extent the engrafted smallpox would develop.

In the year 1747 there was born in England a man who may well be placed as the third culminate in the progress of medicine—Hipocrates, Galen and Jenner. To Jenner belongs the credit for the practical elimination of the horrors of smallpox. He showed a scientific bent of mind early, studied medicine under the famous John Hunter, and while at Sodbury in practice a chance remark of a milk-maid patient was responsible for his interest and contribution to vaccinaton. During one of his visits the subject of smallpox was mentioned. She informed Jenner that to contract the disease in her case was impossible, as she had had cowpox. Again we must give credit to the peasantry for another remarkable observation. It had been known for a long time that the udders of milk cows frequently contained ulcers and pustules, and that similar lesions were transmitted to the hands of the dairymen; further that those who had contracted the cow disease were immune to smallpox.

The simple statement of the dairy maid profoundly affected Jenner. Instead of dismissing her asseverations as a mere superstition, he investigated. After extensive observations, Jenner, in 1780, confided his hopes that cowpox would prevent smallpox. In 1796 he performed his first crucial experiment. Into the abraided skin of the arm of a young man he transferred the pustular matter from the cow. Later this young man was exposed to smallpox without effect. Other experiments established the effectiveness of vaccination. From 1796 to 1823 Jenner's activities were almost solely concerned in convincing the world of the merits of vaccination. He met with bitter opposition. To transmit beastly diseases to men was considered a crime against the Most High. It was reported that bovine heads grew out at the points of vaccination. Children who had been vaccinated were reported to have developed cow faces covered with hair; others to bellow like bulls. These were among the comments of both doctors

and clergy. Jenner lived, however, to see the influential and dominating peoples in the civilized world adopt his preventive treatment. From the chance remark of a peasant to a man with an open scientific mind the world has received inestimable benefits.

To fully appreciate the value of Jenner's contribution one needs but contrast the relative indifference manifested towards the disease to-day with the terror wrought by smallpox in years gone by. The conquests of Cortez and Pizarro were accomplished more through the introduction of smallpox than by the sword. With the Spaniard's entry into South America and Mexico the disease had its inception, and then proceeded to spread like a prairie conflagration. In Mexico 3,500,000 were suddenly slain, and no one remained to bury them. Whole tribes were exterminated in the West Indies. Entire races passed away in Brazil. In Quito 100,000 Indians perished. Certain aboriginal cities were left without a single inhabitant. More terrible still were the ravages of smallpox among the red Indians. Catlin gives a very graphic account of the extermination by smallpox of the Mandan tribe, and how its great chief, Mah-to-toh-pah, the only survivor, sadly reviewed the dead bodies of his own families and warriors before throwing himself down among them, and as a result of total abstinence from food soon joined them on the happy hunting grounds.

IX. BACTERIA.

It was in 1863, two centuries or more after Leeuwenhoek saw the microbe, that the first bacterium of disease was caught and convicted by Davaine and Rayer, although it was previously suspected that this particular microbe—anthrax—was responsible for the holocaust among both cattle and men. For example, in a single district in Russia, during the period of three years, 56,000 horses, cattle and sheep and 528 men died from anthrax infection, or "wool-sorters' disease," as the human infection was termed.

The next two decades saw the discovery of many of the bacteria that are the enemies of man. Microörganisms that enter man, and as a consequence cause diseases, are known as pathogenic. They may belong, so far as can be determined, to either the animal or the vegetable kingdom. The former are referred to as pathogenic protozoa, while the latter are

termed pathogenic bacteria. Even now some question has arisen as to whether bacteria should be classed solely among plant life. At any rate, bacteria are extremely minute. Only the highest power of the microscope can detect them. For them a pin point would make a plateau. In some species 15,000 to 20,000 could stand "shoulder to shoulder" in a straight line and still be within the limits of an inch. One million would not weigh a gram.

No other species of life forms are so ubiquitous. Earth, air and water are the abodes of countless billions. Even snow and ice are their rendezvous. One pint of milk contains millions. We drink and inhale thousands upon thousands daily.

Bacteria propagate by simply dividing. Should one divide to form two new lives, let us say every hour, then 16,613,376 would be the number of progeny at the end of twenty-four hours. It has been estimated that a cholera germ divides every twenty minutes. At this rate five quintillions could claim lineal descent from this prolific ancestor in twenty-four hours. If all bacteria were permitted to indulge in such prolificacy, there would be no room on the face of the earth for other life forms. Fortunately, environment, competition and food supply do not permit of this luxuriant and riotous growth.

Only relatively few bacteria are pathogenic to the human body. Otherwise human life would be impossible. Many species are among man's greatest industrial servants. They till the soil; they serve man in the jute and flax industry; they help to tan; they put aroma into tobacco; wine, beer and vinegar are the products of their activity. Luscious fruits, cheese and butter are flavored by them. Even our daily bread is a product of their noteworthy labors.

Pathogenic bacteria, to repeat, are those members of this important group of life which are destructive to animal life. They flourish and multiply in the protoplasm of animal life. When once an entrance is made into the living flesh they begin to multiply and destroy that in which they grow.

The pathogenic bacteria, as a rule, are classified according to their forms. The slightly elongated, straight, rod-like forms are termed bacilli. If the elongated ones are spirally shaped, then they are called spirilli. Many species of bacteria are spherical in outline, and are known as cocci.

X. PASTEUR.

In 1863, the year of the discovery of the anthrax bacilli, Louis Pasteur turned his attentions toward the study of this disease. To him we are far more indebted than to any one else for the comforts and well-being of humanity to-day. Pasteur was the sower of the modern ideas of medicine. Our practices of asepsis, antisepsis, and vaccinations against destructive diseases are the direct results of the brilliant experiments of this master mind. Certainly Pasteur may be regarded as the modern god of medicine.

Until the entrance of Pasteur into the scientific arena the world was laboring under a false delusion, and one of momentous significance. I have reference to that predominating theory of that time, that life originated spontaneously. The Greeks and Romans firmly held this view. Virgil taught us how to make bees. Aristotle taught that frogs and eels could develop from dead matter. Van Helmont, in the seventeenth century, gives us a prescription for making mice: "If soiled linen be squeezed into the mouth of a vessel containing some grains of wheat, the grains are transmitted into adult mice in about twenty-one days." "To produce scorpions," wrote Van Helmont, "scoop out a hole in a brick. Put into it some sweet basil, crushed. Lay a second brick upon the first, so that the hole may be perfectly covered. Expose the two bricks to the sun, and at the end of a few days the smell of sweet basil, acting as a ferment, will change the herb into real scorpions." Even in our own day some people really believe that mice develop from old rags. How mussels develop from mud, and worms from rotten timberwood which later become butterflies, and then in turn birds, were frequently described in type. Even as late in 1858, Pouchet published a "Note on Vegetable and Animal Protoörganisms Spontaneously Germinated in Artificial Air and Oxygen."

Among thinking men an intense controversy raged throughout the eighteenth and nineteenth centuries respecting this point. The experiments of Father Needham, Abbe Spallanzanni, Schwann, Helmholtz, Schroeder and Dusch, among others, certainly strongly suggested that spontaneous origin of life did not occur.

It was not until 1862 that Pasteur proved conclusively to a skeptical gathering at the French Academy of Science that *"la*

génération spontanée est une chimère." Now *"omne vivum ex ovo"* and *"Omne vivum ex vivo"* are biological axioms. The practical significance of this very valuable contribution of Pasteur will be considered later.

Pasteur was a chemist by training and had devoted much time to the study of fermentation in beers and wines. Especially was he concerned with the determination of those factors responsible for these diseased liquors. He became convinced, as a result of his studies, that the fermentation of beer and wine and the souring of milk were due to the activity of living microörganisms. Although this view had been previously surmised, it remained for Pasteur to bring this truth to its full realization. He even suggested that decay, disease and suppuration were fermentive processes analogous to that in wine. Thus from studies concerned with those articles toward which the bone-dry measure is directed has the happiness and health of mankind been materially increased.

Pasteur next took to the study of anthrax, which had been only recently discovered. He found that it would flourish and multiply in an environment other than blood. He made beef extracts or bouillons, into which he planted the anthrax germs. He noted that in a short time this medium became filled with the swarming bacilli. He studied the effects of temperature, and found that upon addition of certain chemicals the anthrax became less poisonous or attenuated. These attenuated cultures were then inoculated into animals, with the result that the animal became extremely sick, but did not die as was the case when the virulent bacilli were introduced. Later he found that an animal which had been inoculated with the attenuated forms and recovered could withstand a more virulent dose upon a second inoculation. After recovery from the second dose the most virulent cultures of anthrax were ineffective. Thus was the principle of immunity developed and established. As soon as Pasteur had perfected this technique of producing immunity, he announced his discovery to the world. Its reception, like all great truths suddenly advanced, was met by the most contumelious contravention. A commission was appointed to investigate the apparently absurd claims of this French chemist. Was he a charlatan who desired to work his mystic wares upon an ignorant and credulous public? France lost yearly millions of dollars as a result of the havoc reaped

by anthrax. What could stop such waste other than an act of Providence?

From Pasteur's own notes we learn that, "On May 5, 1881, twenty-four sheep, one goat and six cows were inoculated with an attenuated form of anthrax. On the following May 7, these were reinoculated with a more virulent culture. On May 31, the same animals were again inoculated with the most virulent bacilli, along with a corresponding number of animals which had not been previously inoculated. Two days later he had the extreme satisfaction of demonstrating to the commission the results of his experiment. Not one of the immune animals demonstrated the least signs of infection, while in the nontreated group all were either dead or seriously affected.

The most fascinating, if not the most romantic of Pasteur's labors, were associated with the conquest of hydrophobia or rabies. The appalling effects of the mad dog's bite has been known since time immemorial. One of Homer's warriors calls Hector a mad dog. Aristotle described the disease. Celsus recommended that a victim of the bite be held under water until almost drowned. Van Helmont, he of mice-making fame, recommended that Celsus's treatment be applied until the whole Psalm "Miserere" be sung. Perhaps in some instances it would be far more pleasant, even unto death, to be fully immersed during the vocal execution of the Miserere by some tremulous prima donna. Still such a procedure could never be made a standardized practice.

Many other therapeutic measures had been devised for rabies. Bleeding the patient nigh unto death, starvation, or both of these procedures combined, a diet of mad dog's liver, and drinking the blood of the mad dog, were some of the practices in vogue. One of the most common practices was suffocation. Either the victim was drowned or suffocated, by some such means as compression between two mattresses. As late as 1810 France passed a law prohibiting drowning or suffocation of hydrophobia victims. It is impossible for us in this day to realize the extreme horror with which the disease was held. Always regarded as incurable, it was a frequent practice for parents to lead the child who had been bitten to some pond or stream and there drown it. Such customs were by no means uncommon in Europe up until the time when Pasteur turned his attention to the study of rabies, in 1880.

No doubt the memory of a rabid wolf that attacked and killed a host of Pasteur's associates when he was a child of eight years impelled him to begin its study. He soon demonstrated that the poison introduced by the diseased mad dog located itself in the brain and cord, and that by making emulsions of the central nervous system of dogs dead from rabies, and inoculating the emulsion into the brains of normal dogs, the latter would contract the disease in fourteen days. Likewise he gave the disease to rabbits, and further learned that after successive inoculations of rabbits the infectious agent in hydrophobia became ever so much more virulent. By drying the spinal cord or brain removed from the rabid rabbit, the virulence would decrease daily until the fourteenth day, when it would entirely disappear.

With this knowledge gained after much patient study, Pasteur began his famous production of immunity. He made emulsions of the fourteen days' dried rabid cord, now innocuous, and injected it into a normal dog. The next day an emulsion of thirteen days' dried rabid cord was inoculated into this dog. On the third day a twelve-day cord was likewise injected, and so on until the dog had received fourteen injections of cords varying from fourteen days old to one day old. Each succeeding inoculation was thus more virulent than the preceding. It was soon demonstrated that a dog so treated was impervious to hydrophobia. The most rabid dogs were permitted to lacerate these treated dogs, without effect. Pasteur, in March, 1885, announced to the scientific world that he had succeeded in producing dogs immune to hydrophobia, and on July 6, following, little Joseph Meister was bitten. Pasteur utilized his method of producing immunity in dogs and began the famous treatment of the boy. Madame Pasteur's account of his conduct during this experiment is most interesting. Almost wrecked with apprehension, he continued the treatment while little Jo played with the rabbits and guinea pigs in the laboratory. The boy did not develop the disease, and became the first successfully treated patient for hydrophobia in history.

As knowledge becomes more or less universal, the contributions of Pasteur will be generally heralded as the most priceless of all the contributions made by that galaxy of great men to whom the world is indebted for its welfare and progress.

XI. LISTER AND ANTISEPSIS.

Until this time no attempts were made to clean and sterilize wounds. If the foul, deadly suppuration was due to some reaction between exposed flesh and air, why should concern be manifested towards maintaining a clean wound? A scratch in that day was as fatal as a bullet wound of to-day. One needs but to familiarize himself with surgical history of former European wars to realize the enormity of infection. It is said that during Napoleon's campaigns it was found to be far more expedient to place slightly wounded soldiers—soldiers with wounds which in this day would be regarded as trivial, and would not greatly incapacitate them—before the firing squad. Dead soldiers were far more valuable than infected soldiers. Our greatest human catastrophies of the Civil War were ones of infection. Practically every head and abdominal wound proved fatal. A driver of one of the ambulances in that war was asked if he knew how to treat wounded men. "Oh, yes," he replied, "if they are hit here (pointing to the abdomen), knock 'em on the head."

Then for years there was the great waste of life in both private and hospital practice. Hospitals were known as veritable houses of death, and, like Dante's Inferno, the gates might well have borne these words in somber color: "All hope abandon, ye who enter in." Great loss of life was especially experienced in the lying-in hospitals, where practically every mother, after giving birth to her offspring, left the wards in coffins. In the Munich *krankenhaus* 80 percent of all wounded became gangrenous. In 1868 the death rate alone for amputations was 60 percent. Lingo Porto, a famous Italian surgeon, regarded the patients in his hospital chiefly as material for his museum.

Such was the indescribable horror of the day when microbes were considered the direct products of reaction between air and flesh.

Following up Pasteur's incontrovertible demonstration, Lord Lister began his famous studies of asepsis and antisepsis. Carbolic acid was found to be a splendid antiseptic, and as a result of the untiring efforts of this man, who had obtained the master idea from Pasteur, humanity to-day sits firmly ensconced with wounds which formerly would have been fatal, but now are regarded as nothing more than temporarily inconvenient.

XII. FAMOUS PATHOGENIC BACTERIA.

In 1867 one of the most important of pathogenic germs—streptococcus—was caught red handed. In association with other germs, it is responsible for suppuration, which once caused so much destruction of life. Now we know that several species of streptococci exist, and that they are largely responsible for such serious diseases as tonsilitis; endocarditis, in which the valves of the heart are destroyed; and arthritis.

Staphylococcus, an intimate associate of the streptococcus in wound infections, was not discovered until the years 1884 and 1885.

The *Bacillus lepræ* was discovered by Hansen, of Bergen, in 1872, and now it is universally recognized as the cause of leprosy. The disease appears to have prevailed in Egypt 3000 to 4000 B. C. The Hebrew writers frequently refer to it. India, China, Greece and Rome in ancient times were familiar with the disease. It appears to have reached its culmination during the Middle Ages, when it was prevalent all over Europe. It is said that there were at least 20,000 leper asylums during the sixteenth century. Since then the disease has greatly declined. To-day it is more or less confined to China, Australasia, the Philippines, the Sandwich Islands, West Indies, Mexico, Norway, Sweden and Russia. The bacillus resembles in many respects the tubercle bacillus. Contrary to the general belief, it is not highly contagious.

The spirillum of relapsing fever, so common to the southern Russian peasants, was first seen in the blood of its victims in 1873.

Many microbes depend upon some kind of carrier for their preservation and deposition into living flesh. Usually these carriers are insects, such as flies, mosquitoes, lice, ticks and bed bugs. The microbe patiently lives within the intestines of their carriers until the latter find their victim. Then as the carrier proceeds to fill up on the blood of the victim, the microbe makes its double-quick entry into the circulation of man and begins to propagate in this new and conducive environment. In case of relapsing fever the bed bug serves as the carrier.

The *Diplococcus intracellularis* was discovered and described by Weichselbaum in 1877. Since then this germ has been found to be the etiological factor in epidemic cerebrospinal

miningitis, which is a very fatal disease. At least four serious outbreaks have been recorded. During the first period, 1805 to 1830, the disease was very prevalent in the United States. The second period, 1837 to 1850, was marked by a serious epidemic in France. During the third period, 1854 to 1874, an outbreak occurred in both the United States and France. The fourth period began with 1875 and continued up until recent years. There have been many serious epidemics in different places during this period. Much credit is due Flexner and his collaborators for an antimeningococci serum which has proved to be efficacious in many cases in the treatment of the disease.

In the early eighties a number of the most destructive bacteria were isolated. In 1880 the bacillus of typhoid fever was discovered. This dreaded disease has doubtless claimed millions of victims in the past, and even to-day approximately 180,000 people in the United States annually suffer from the infection. At least 18,000 die as a direct result of the disease. We cannot even conjecture how many die or are impaired for life from the indirect results of these minute engines of destruction. Typhoid fever and war have always been inextricably associated. This fever was the chief source of our fatality during the Spanish-American War.

With the discovery and isolation of a specific microbe, many phases of study must be devoted to it. Its resistance, growth and methods of dissemination are some of the important aspects from which it is considered. We have learned so much regarding the habits and habitats of the typhoid bacillus, and ways of preventing contamination therefrom, that we may now regard it, like smallpox, as an optional disease. We know that it is strictly a human infectious organism, and that it confines its chief destructive activities to the intestinal tract. It may live for a long time in water and the damp earth. As it is specifically a human disease, typhoid bacilli must always have their origin from human excrement. It is a well-known fact that one who has recovered from the disease may continue to carry and disseminate typhoid bacilli for years afterward. Man, running water and flies are some of the chief agencies of dissemination. Infection can only occur through ingestion. Water, milk, vegetables or prepared foods that have become contaminated through the agencies of man or flies are the chief sources by which infection occurs. To obviate all these sources

of dissemination and to destroy all contamination which may have occurred of the food and water taken into the system is a positive insurance against typhoid fever. An additional precautionary measure is vaccination—one of the great accomplishments of the age based upon Pasteur's master contribution.

XIII. ROBERT KOCH.

In 1881 another genius entered the field of disease conquest. Robert Koch was a country physician, and when his remarkable work in bacteriology was begun he possessed none of the equipment we now regard as indispensable to its study; yet Koch's achievements have never been equaled. He has rightly been called the Father of Bacteriology. It was he who ferreted out perhaps the most destructive of all these minute missiles of death—the tubercle bacillus, which he discovered in 1882. Up until the time that Koch magnanimously presented to mankind the results of his inestimable labors, tuberculosis was the most despairing of diseases. That the disease is heritable was the universal conception, and as a consequence family after family for generations unnumbered were exterminated. It seemed useless to attempt to combat its insidious onslaughts when the disease was considered theirs by hereditary transmission.

A most resistant germ is the tubercle bacillus. It may live for months in dark places. It resists to some extent both the warm, dry, penetrating rays of the sun or the temperatures of ice and snow. Its chief portal of entrance is the respiratory tract, although the mouth also is a highway of the ingression. The bacilli may enter through abrasions in the skin. The chief source of dissemination is from the consumptive himself. With each careless expectoration millions of germs are released, which await other victims. When the sputum dessicates, the microbes firmly ensconce themselves upon veritable aëroplanes of dust particles. The wind or the broom of the good housewife then sends them on their journeys of destruction. They may gain entrance into the mouths of babes as a result of the omnivorous habits infants have of sucking every prehensible object, no matter the extent of contamination. No wonder, then, that the disease was regarded as fundamentally a heritage. Again, tubercle bacilli may enter the digestive tracts of infants through milk from infected cows. It is now generally held that bovine tuberculosis is pathogenic to man.

Nor must we forget the role that the filthy house fly plays in transferring the germs from infected sputum to food.

The tubercle is both aristocrat and proletariat, as it attacks both rich and poor alike. Spinoza philosophized while his very lungs were being devoured. Likewise Schiller, Sterne and Keats were early victims of the disease. Stevenson's years were early numbered, and Chopin composed his own funeral march to the note and rhythm of the invincible and fatal advance of these minute destroyers within his body.

Propably one million and a half of the world's population succumbs annually to tuberculosis. The mortalities at the Marne, the Somme and Verdun, excruciating as they have been to our sense of humanity, do not equal in numbers the yearly victims of tuberculosis. In the United States alone 150,000 are destroyed. With what horror and wrath would we receive word that 100,000 of our young men had been slain in France! Yet at our very doors murder of even more gigantic proportions goes on, and with every victim countless millions of destructive mines are sown which only await the unsuspecting passer-by.

As a result of Koch's triumph, and a host of workers who have followed him in the investigation of tuberculosis, the disease has been robbed of much of its terrors. We no longer regard it as a heritage. Further, we have learned that cleanliness, fresh air, sunlight, substantial food and the maintenance of high bodily resistance are the catholicons of prevention and cure. All patent medicines purporting cure should be shunned.

In 1886 cholera began its sixth gigantic and destructive march from Asia into Europe. Cities were left without a single inhabitant. When it was heralded in Europe that cholera had once more broken out and was running amuck, a number of young scientists went to Alexandria with a view of determining its etiology and combating the disease. Quiller, one of the great martyrs to man's welfare, lost his life. It was Koch who first isolated the germ—the comma bacillus of cholera. He then went to India, the breeding hole of this microbe, and there offered his services to the British government. He was not well received; the attitude of the officials there was one of wonder why a German scientist should concern himself with British affairs. At the present time there

might be some reason for such a reception, but at that time it was inexcusable. Discouraged, Koch returned to Germany, and even there his claim of discovery of the specific microbe concerned in cholera was met with scepticism and derision. Even Professor Pettenkofer, a famous bacteriologist, refused to accept the apparently harmless little comma bacillus as being responsible for the dreaded cholera. To prove his contempt for Koch's claim, it is said, he drank a suspension of the germs—a veritable cholera high ball. After a lingering and almost fatal illness, Pettinkoffer fortunately recovered—needless to say, converted to the efficacy and specificity of Koch's germ in the production of cholera.

Cholera is closely akin to typhoid fever, but much more fatal in its effects. Its origin, its methods of dissemination and its means of entrance are similar to that of the typhoid bacillus. It is specifically a human disease. The average annual mortality from this disease for the years 1898 to 1907 in India was 336,378. Much credit is due Haffkine, Nicholi and others, who have studied the germs and developed a vaccine for the disease. According to one report, among 40,000 who have been vaccinated only six contracted the disease.

Perhaps the most spectacular of all microbes is the one discovered by Kitasato, and responsible for bubonic plague. *Bacillus pestis* is the term applied to this particular germ. From time immemorial this pestilence has existed. In Samuel we find biblical reference to its occurrence among the Philistines. The world has passed through three great epidemics of plague. The first originated at Pelusium, in Egypt, in 542 A. D. By following the great trade routes, it soon spread by one route to Alexandria on the north, and by another into Asia, and then to all the known world. At the height of this epidemic, according to Procopius, an observer, from 5,000 to 10,000 died daily.

The second great epidemic of plague is known in history as the black death. It originated, so far as can be determined, in Mesopotamia about the middle of the eleventh century. It is thought that the returning Crusaders during the twelfth and thirteenth centuries assisted in its recrudescence. Again the disease followed the trade routes, and this time it penetrated even farther into Europe. During the epidemic some 25,000,000 people, or one-fourth of the population of Europe, per-

ished. It is said that at the siege of Gaffa, in Crimea, by the Tartars, 1346, the city appeared impregnable. In the meantime plague broke out among the besiegers, and to them apparently the city was lost. Suddenly it occurred to one of the besieging generals to throw into the defiant city, by means of a catapult, a dead victim of plague. The disease spread like wildfire among the besieged. This act alone caused the fall of Gaffa, and from there the plague was carried to Constantinople by the escaping besieged.

At present there still exists the smoldering remnants of the third epidemic of plague which originated in China in 1871. From there it spread to India, where 6,000,000 natives died within the period of ten years. It has appeared in the principal seaports of the world since then. Only two years ago it appeared in New Orleans. The vigilant activities of the United States Public Health Service soon stamped it out.

Plague is primarily a rat infection, and is transferred from this animal to man by the flea. Eradication of these two carriers will assure man's freedom from this fatal infection.

XIV. DIPHTHERIA AND TETANUS.

The decade following 1880 was remarkable for the discovery of many of the important pathogenic bacteria. In 1883 Klebs found in the false membrane of the throats of children, who had been choked to death from the extremely prevalent and dreaded infection known as diphtheria, the specific germ responsible for the disease. The year following Loeffler found that he could produce the disease in rabbits and guinea pigs. He learned, however, that it was first essential to abraid or scarify the mucous membrane of the throats before the animals would contract the disease. A noteworthy observation this was, for from it we have learned of the dangers of colds. Colds, like the experimental scarification of Loeffler's, break the continuity of the protective mucous membrane and permit other dangerous germs to gain entrance into the system. Therefore, a cold may be the forerunner of tuberculosis, scarlet fever, diphtheria or other serious and fatal infections.

During the time that Klebs and Loeffler were busy with experiments regarding the diphtheria bacillus and its habits, Von Behring and Kitasato isolated the peculiar drum-stick-like bacillus which is responsible for lockjaw or tetanus. This germ

has a wide distribution, and its spores are found wherever there is dirt. Barnyards are veritable repositories for them. Rusty nails appear to be rendezvous. Even the dirt that besmears the healthy living child may contain millions of these spores of tetanus bacilli. The spores can only grow when they gain deep entrance into the body and are shut off from oxygen.

It is known as the Fourth of July bacillus. It was once a custom to exhibit our copious and excessive patriotism with every form of pyrotechnic art. Frequently, premature explosions of the firecrackers, etc., drove the accumulated dirt on the hand, with its numerous spores, deep into the skin, and, as a rule, the obituary column of the local press within a few days would announce the subsequent fate of many of our little patriots. Tetanus has been responsible for immense loss in the livestock industry as well.

The tetanus bacilli was duly convicted by Von Behring and Kitasato as being responsible for lockjaw. But the bewildering problem to them was, How did it accomplish its dire results? It will be recalled that Davaine and Rayer found the blood of anthrax victims swarming with the microbes—a condition sufficient to account for the relation of the germ to the disease. Not so, however, in the case of tetanus. The most diligent search failed to reveal the germ in the blood of their victims. How, then, did it act in its murderous onslaughts? Further study and experimentation proved that the germ in itself was more or less innocuous, but that its excretion, or the by-products of its metabolism, was the real poisonous agent. This led to a new conception of the destructive action of pathogenic bacteria. It is not the presence of bacteria in themselves that kills, but the poison, or toxin, they produce or eliminate as a result of their growing activities.

It is, then, the toxin from tetanus that slays. The poison is absorbed by the blood and carried to those vital centers in the brain and cord, and there irritates and paralyzes the nerves which control the muscles and vital organs. Tetanus toxin is in all probability the most poisonous agency known. A fatal dose of strychnine ranges from 30 to 100 milligrams, while .23 milligram of the tetanus toxin proves fatal. In other words, it is from 120 to 400 times more poisonous than strychnine. A drop or two of this poison injected into the elephant would result in its death.

The admiration and gratitude of the world are due these modest, indefatigable pioneers in medicine. As soon as some new truth was ascertained it was published without material gain. Thus ideas were exchanged and great progress was made. Contrast this spirit with the modern commercial patents now granted for any and all insignificant devices.

As soon as Klebs and Loeffler learned of this idea of toxins from Von Behring and Kitasato, their perplexities were ended, for they could find the diphtheria bacilli in the throats of the victims, but never in the blood.

Von Behring and Kitasato, acting upon Pasteur's inspiration and suggestion, developed immunity for tetanus. This was accomplished in a manner much similar to that utilized by Pasteur—first attenuation of the poisonous toxin followed by repeated, increasing injections of the toxin into the blood. After this has been accomplished in the case of one animal it can successfully withstand a dose of toxin that is sufficient to kill a thousand like animals which have not been immunized. Later, it was learned that the blood of the immunized animals would, when injected into normal animals, cause immunity. Here, then, we have the discovery of another great principle of modern medicine, and that is, in the case of tetanus, that the blood or serum of an animal which has been immunized by repeated, increasing injections of toxin, will cause another animal to become immune when this sensitized serum is injected into it. This serum is known as antitoxin.

After this great discovery had been magnanimously heralded to the world, we find that the next great triumphal advance came from across the Rhine. Roux and Yersen, in Pasteur's laboratories, began their monumental labors in the study of diphtheria. With the idea of antitoxin contributed by Von Behring and Kitasato, they set out to ascertain if diphtheria would react in a like manner. It was found that such was the case. However, twelve long years of labor passed before the most suitable animal was found in which to develop the antitoxin. Ultimately the horse proved to be that animal, and now thousands of horses are used for this purpose. The process of making the antitoxin in brief is as follows: The diphtheria bacilli in countless billions are grown in a bouillon. When sufficient toxin has developed they are destroyed by heat. The

bouillon is then filtered, and the filtrate, which contains the toxin, is then used in producing the immunity. At first a very small amount of diluted toxin is injected into the horse. After it recovers from this inoculation a second larger and more virulent injection of toxin is introduced. Recovery from this second is followed by a third injection of still larger proportions, and so on until the horse reaches the desired immunity. Then a certain amount of blood is drawn from it. The serum which contains the antitoxin bodies is separated off from the other elements of the blood and distributed as diphtheria antitoxin.

Of the inestimable value of Roux and Yersen's contribution little need be said, for the majority of us remember the extreme apprehension caused by diphtheria epidemics prior to 1896, when Roux and Yersen gave antitoxin to humanity. In those days diphtheria and death were almost synonymous terms. Especially severe was this disease in such cities as Paris, Odessa and Rome. When some little member of the household began to show signs of the development of the false membrane in the throat, it was led away by an officer of the law to some isolation hospital. The fond parents had little upon which to base any hope of its being brought back to them in life. Assuredly Roux and Yersen have robbed diphtheria of its horrors.

XV. PNEUMONIA AND INFLUENZA.

Another representative pathogenic bacterium is the pneumococcus, which is the chief etiological factor concerned in pneumonia. In old age especially is the disease almost invariably fatal. The longer one lives the greater are the chances that pneumonia will usher one out of this world of action. Efforts, and with some degree of success, are being made to develop a vaccine both for the prevention and cure of pneumonia. If this is successfully accomplished the span of life should be materially increased.

The bacillus responsible for influenza or la grippe was isolated by Pfeiffer in 1892. Great pandemics of this disease have been recognized since the sixteenth century. There were four, with their succeeding epidemics, during the last century. The last pandemic seems to have begun in the East. According to Osler, it prevailed in Buchara in May, 1889. It reached Moscow during the following September, St. Petersburg in October,

Berlin in November, London during the middle of December, and by the end of this month it had reached New York. The duration of an epidemic in any one locality is about six weeks. There is no disease of modern times that attacks indiscriminately so large a portion of the inhabitants. Fortunately the mortality is low.

XVI. CARRIERS OF DISEASE.

Already the relation of the bed bug to relapsing fever has been mentioned. The flea has been convicted of inoculating mankind with the black death. The cockroach, along with the fly, is now being accused of being an active agent in promiscuously scattering the destructive seeds of typhoid fever and tuberculosis. The stable fly is now being suspected of inoculating into man such grave diseases as infantile paralysis and meningitis.

Certain insects, however, are responsible for dissemination of specific microbes, and only through specific insects are certain diseases contracted. For example, it is through the medium of the louse alone that the disastrous typhus fever attacks man. Likewise the fatal Rocky Mountain spotted fever of Montana can be contracted only through the bite of the tick.

In the war on, and subjugation of, the pathogenic microbes, the destruction of these carriers is as efficacious in the elimination of a disease as is the destruction of the germ itself. Two notewcrthy diseases, malaria and yellow fever, which have profoundly affected the activities of man, are now being vanquished as a result of war against the carriers.

Malaria is due to an animal microörganism, discovered by Laveran in 1880, which enters the red blood cells and there saps out the function and vitality of these important cells. How these devitalizing protozoan organisms gained entrance into the blood stream was an important and perplexing problem. This was finally settled by Major Ross, of the English army, who demonstrated that a certain genus of mosquito—*Anopheles*—was responsible for injecting the microbes into man. This mosquito imbibes the protozoan from marshes or infected blood, and it then lives and multiplies in the intestines of the mosquito after which it is inoculated into man when the mosquito sucks its diet of blood.

To prove that the *Anopheles* is responsible for malaria, men

offered themselves as martyrs. The humanitarian and unselfish devotion of such men as Manson, Samborn, Low and Terzi, in living among the malaria infected swamps of Greece in order to prove the deadly rôle that the *Anopheles* play in the misfortunes of man, is worthy of all praise. Truly such men should have monuments erected to their memories in order to remind mankind of their sacrifices to the welfare of humanity.

The mosquito has been a very important factor in the affairs of man. Let us quote from Ronald Ross's paper on "Malaria in Greece."*

"In prehistoric times Greece was certainly peopled by successive waves of Aryan invaders from the north—probably a fair-haired people—who made it what it became, who conquered Persia and Egypt, and who created the sciences, arts and philosophies, which we are only developing further to-day. That race reached the climax of its development at the time of Pericles. Those great and beautiful valleys were thickly peopled by a civilization which in some ways has not been excelled. Everywhere there were cities, temples, oracles, arts, philosophies, and a population well trained in arms. Lake Kopais, now almost deserted, was surrounded by towns whose massive works remain to this day. Suddenly, however, a blight fell over all. Was it due to internecine conflict or to foreign conquest? Scarcely, for history shows that war burns and ravages but does not annihilate. Thebes was thrice destroyed, but thrice rebuilt. Or was it due to some cause entering furtively, and gradually sapping away the energies of the race by attacking the rural population, by slaying the new-born infant, by seizing the rising generation, and especially by killing out the fair-haired descendants of the original settlers, leaving behind chiefly the more immunized and darker children of their captives won by the sword from Asia and Africa? Could it (the malaria) not have been introduced into Greece about the time of Hippocrates by the numerous Asiatic and African slaves taken by the conquerors? Supposing, as is probable, that the *Anophelines* were already present, all that was required to light the conflagration was the entry of the infected persons. Once started, the disease would spread by internal intercourse from valley to valley, would smolder here and blaze there, and would, I think, gradually eat out the high strain of the northern blood.

"I can't imagine Lake Kopais, in its present highly malarious condition, to have been thickly peopled by a vigorous race, nor, on looking at those wonderful figured tombstones at Athens, can I imagine that the health and power people represented upon them could have ever passed through the anemic and splenomegalous (to coin a word) infancy caused by widespread malaria.

"The whole life of Greece must suffer from the weight which crushes its rural energies. Where the children suffer so much, how can the country create that fresh blood which keeps a nation young?"

* Macfie, The Romance of Medicine, pp. 160-162.

Quoting from Macfie: "The Turk and mosquito together have destroyed Greece, and perhaps the mosquito has been the most destructive. Little did the Greeks know that the blood of the slaves they imported swarmed with microbes that would devour there mighty civilization. Yet so it seems it was. Nemesis is a gnat."

Although the offending microbe of yellow fever has not been determined, yellow fever has been practically stamped out. Especially after the meritorious labors of Ross, it was suspected that some species of mosquito was responsible for the transmission of malaria. Search for the insect was initiated by Sternberg, Reid, Carroll, Lazear, and others of the American Army Medical Service in Cuba during the summer of 1900. Eleven men volunteered for the experiment. They permitted mosquitos which had previously fed on yellow-fever patients to bite them. Doctors Carroll and Lazear contracted the disease, and the latter died. Thus was the *Stegomyia* "caught with the goods."

After having demonstrated that this mosquito was responsible, Doctor Reid and associates began experiments to ascertain whether the disease could be propagated, as was the current belief, by clothing, bedding and other articles, from yellow-fever patients. Into a specially erected, nonventilated, dark building, contaminated clothes from the beds of yellow-fever patients were dumped. This bed clothing was saturated with the vomitus and excreta of the patients. Assuredly it required the great courage of brave and unselfish men to enter this odious, fetid, foul house of the dead. Yet that is exactly what the volunteers did, and they remained there several days under these most loathsome conditions. None contracted the disease, however, thus heroically demonstrating that yellow fever is not contagious by association, but depends solely upon the mosquito *Stegomyia* for its transmission.

The inhabitation of the luxurious tropics is now a matter of the eradication of this mosquito.

XVII. MICROBES AND NATIONS.

Already have we learned that microbes—these silent, invisible instruments of death—have played a great rôle in the affairs of man. Without doubt the hæmamœba of malaria and the tubercle bacillus have been two great factors in the rise and fall of nations. Microbes not only have destroyed nations, but

have builded them as well. Perhaps to the tubercle bacilli England owes her supremacy. Columbus discovered America, but the bacillus of tuberculosis conquered the northern half. The hæmamœba, however, on the other hand, defended the southern half against the Spanish and Portuguese invaders.

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